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REPRODUCTION BY BUDDING IN DROSERA*

In August, 1907, young plants were found growing from old leaves of *Drosera rotundifolia* (Fig. 1) in the propagating houses of the New York Botanical Garden. At first they were thought to be seedlings but further observation showed that they had no cotyledons, no nepionic leaves like those of seedlings, no roots with one exception (Fig. 5), while they bore glandular foliage leaves like those of the adult plant except in size. Hence it was evident that the young plants were produced from the budding of the old tissue. In some cases the leaves upon which they grew were green and apparently normal; in others, brown and decaying.

Microtome sections through the point of connection between the young plant and the parent tissue (Figs. 2 and 3) showed no union between the vascular tissue of the parent plant and that of the young plant. A differential stain (Haidenhain's iron haematoxylin) showed the difference between the vigorous tissue of the young plant and the disintegrating tissue of the parent plant very clearly, but Delafield's haematoxylin showed no such distinction.

In each case, the stem of the young plant gave rise to five or six leaves before the root appeared as a lateral outgrowth. The root had a red apex and was diageotropic until it had passed beyond the margin of the old leaf, when it bent downward into the sphagnum in which the original plants were growing. In one case only (Fig. 5) was a root observed on the under (non-glandular) surface of the leaf. Later, leaf-petioles and one flower-stalk (Fig. 6) that had accidentally been broken from a plant were found to be proliferating in a similar way.

This growth from an inflorescence is noteworthy because so

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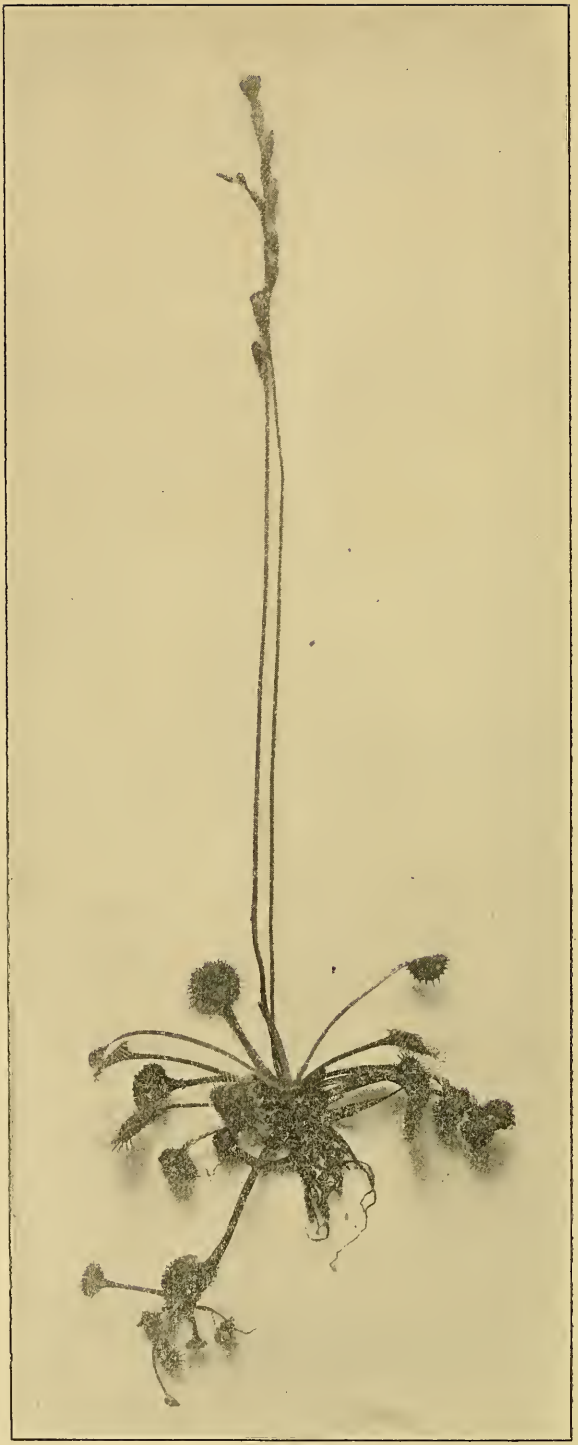
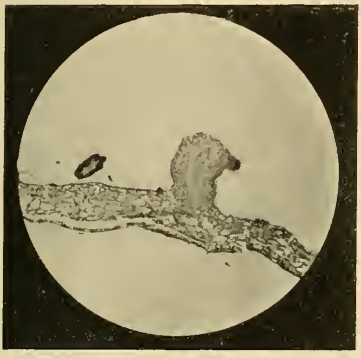


FIG. 1. *Drosera rotundifolia*, showing a young plant growing from leaf.

few examples have been reported (Kupfer, Mem. Torr. Bot. Club **12**: 224. 1907; Robinson, Plt. World 8: 131. 1905). Plan-



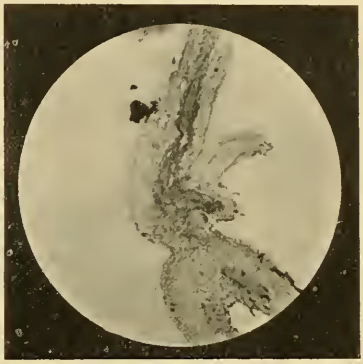


FIG. 2. Photomicrograph of section through an old leaf in region from which young plant is developing.

FIG. 3. Photomicrograph of section through a leaf petiole which bears a well differentiated plantlet. There is no connection between either of the vascular bundles of the petiole and the vascular tissue of the young plant.

chon (Ann. Sci. Nat. III. 9: 84. *pls. 5 and 6.* 1848) described and figured flowers of *Drosera intermedia* which had passed into a chloranthic condition. The petals and the valves of the ovary

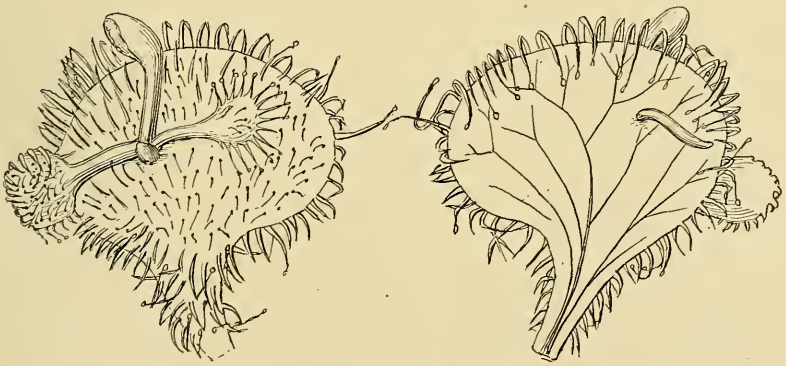


FIG. 4. Leaf upon which young plant is growing.

FIG. 5. Dorsal surface, showing root protruding.

were provided with stipules, bore glands, and were circinate in vernation. Leavitt (Rhodora **7**: 14. 1905) described a similar

aberrant form of *Drosera rotundifolia* but neither observer recorded the development of young plants from the flower-stalks.

To determine whether it was necessary that a leaf should be in connection with the parent plant in order to proliferate, two leaves cut from a mature plant were placed on sphagnum in a moist chamber September 7. One month later a bud was seen upon the surface of one leaf. Three months from the date of beginning

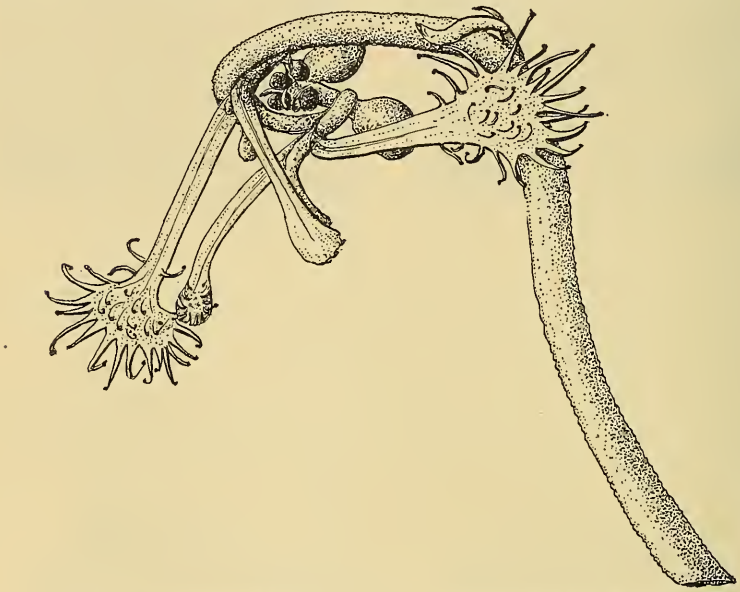


FIG. 6. Flower stalk from which two young plants are growing.

the experiment (Dec. 3) the parent leaf was still green, the leaflets of the young plant were like those of the adult, except in size, and the internodes of the stem were proportionately long, but no root had developed. At the end of four months (Jan. 3) a root was observed which had grown laterally from the base of the stem, while the parent leaf had entirely decayed. This was repeated with four leaves with practically the same results. A portion of a leaf was able to produce a new plant as readily as an entire leaf. Leaves placed with the gland-bearing surface downward in the moist chamber did not produce buds, and all the buds which appeared upon leaves still attached to a plant were upon the upper or ventral side of the leaf.

Nitschke (Bot. Zeit. **18**: 57. 1860) described reproduction by budding in plants of *D. rotundifolia* growing in their native bogs. He observed that while the bud-formation from the leaf surface occurred throughout the summer it was especially frequent in the fall. The buds always developed from the upper side of the leaf. He compared the plant arising from the bud with the seedling and noted that the bud-plant had only a stem-root while the seedling had numerous roots at the base. The first leaves of the bud-plant resembled the mature leaves while the seedling had cotyledons each with a single stoma, and nepionic leaves without glandular hairs. Both the bud-plant and the seedling were caulescent during their first year's growth and attained their rosette form at the beginning of the second season, though bud-plants produced in spring in some cases gained the rosette form during the summer. The first leaves made an acute angle with the stem but the angle made by succeeding leaves increased until it became 90° and the rosette form was reached. Drought tended to hasten the production of the rosette form, while fully developed plants placed under moss produced elongated axes like those of their early form.

Grout (Am. Nat. **32**: 114. 1898) noted adventitious buds on the leaves of *D. rotundifolia*, also the occurrence of glandular hairs a short distance from the base of stems of young plants. The latter observation corresponds with a statement made in Nature (**15**: 18. 1876) that plants of *D. rotundifolia* exhibited at the Chester (England) Society of Natural Science showed elongated axes which produced leaves and glandular hairs alternately.

Similar proliferation of the leaf tissues of *D. intermedia* was recorded by Naudin (Ann. Soc. Nat. II. **14**: 14. *pl. 1. f. 6.* 1840). Two plants developed between the mid-vein and margin of the leaf which had rosettes of leaves like those of the mature plant. The lower surface of the budding leaf was perfectly intact and there was no indication of a root.

The appearance of buds upon leaves of *D. longifolia* was reported by Kirschleger (Bull. Soc. de France **2**: 723. 1855).

Winkler (Ber. d. Deutsch. Gesell. **21**: 105. 1903) noted

reproduction in *D. capensis* as arising not from latent embryonic tissue but from ordinary epidermal cells at the apex or near the petiole of the leaf, or upon the petiole itself.

Goebel (Einleit. i. d. exp. Morph. d. Pflanz. 196. *f.* 97. 1908) describes and figures a portion of a leaf of *D. binata*, a species whose leaves fork into two long segments. If a part be cut away and placed in a moist chamber it develops adventitious shoots, which have leaves like those of *D. rotundifolia* instead of being like the parent plant in form. This is the only species so far observed, in which young plants which arise by proliferation from mature tissue, develop leaves different from those of the adult. The question arises as to whether *D. rotundifolia* is not near to the antecedent form in structure while *D. binata* may be the result of the greatest modification, so that it is still in a state of variation and hence reverts to the *D. rotundifolia* type.

An allied form of reproduction which occurs in *D. pygmaea*, a native of southern Australia and New Zealand, is described by Goebel (Flora 98: 324. 1908). The leaves are arranged in a rosette like those of other species but they are peculiar in having a peltate form and little chlorophyll, the work of assimilation being carried on chiefly by the petioles which are fleshy, contain much chlorophyll, and have stomata. At the close of the vegetative period, in the latter half of October in cultivated plants, numerous brood-bodies which resemble the gemmae of *Marchantia* appear in the center of the rosette. Each is borne upon a slender hyaline stem, the turgid cells at the apex of which set up such a tension that the brood-bodies are easily broken off by the animals which pass over them or by the rain. These small (0.730 mm. by 0.515 mm.), heart-shaped brood-bodies show dorso-ventral differentiation, the under side being smooth while the upper side is rounded into a horse-shoe-shaped cushion. There are stomata on both sides and a vascular bundle runs from the point of attachment to the center of the brood-body. The tissues are rich in starch, fat, and other reserve foods. The anlage of the new plant lies in the hollow at the base and may develop immediately after separation from the parent plant if conditions are favorable, drought being the most serious hindrance. The

first leaves are peltate like those of the adult while the nepionic leaves of the seedling are simpler in form. Goebel believes that the origin of the brood-body is from a leaf anlage which explains their appearing alternately with the foliage-leaves, also the development of a slender vascular strand. It is more difficult to correlate particular parts. At first one is inclined to homologize the blade of the foliage-leaf with the brood-body and the petiole of the foliage-leaf with its stem. However the petiole of the leaf is more strongly developed than the blade, while the stem of the brood-body is less developed. Stipules which appear very early in the formation of the leaf have no homologue in the brood-body. The foliage-leaf is curved so that the apex is directed inwards while the brood-body remains upright. The brood-body develops early from the leaf-anlage and its stem must be regarded as a new structure, the function of which is the dissemination of these reproductive bodies. The part homologous with the foliage-leaf is a group of cells which arises on the inner side of the anlage. No axial buds have been observed in the inflorescence of *D. pygmaea* so it seems reasonable to regard the brood-bodies as new structures which do not arise from axial buds.

From the above observations it is seen that reproduction by budding occurs in *D. rotundifolia*, *D. intermedia*, *D. longifolia*, *D. binata*, and if the brood-bodies of *D. pygmaea* be taken as aborted leaves, the reproduction is by budding in that case also. In each species except *D. binata* the first leaves of the young plant resemble those of the adult. In *D. rotundifolia* at least, the resulting form is the same whether the young plant arises from a leaf still attached to the plant, a leaf cutting, or a flower-stalk removed from the plant.

Whether this is regarded as regeneration or not, depends upon the definition of regeneration which is accepted. Morgan (Regeneration, 23. 1901) says, "The word Regeneration has come to mean in general usage not only the replacement of a lost part but also the development of a new, whole organism, or even a part of an organisn, from a piece of an adult, or of an embryo, or an egg." Goebel (Einleit. i. d. exp. Morph. d. Pflanz. 136. 1908) expresses his idea of regeneration as the phenomenon of

completion or restoration of a plant body after injury without regard to the manner in which it occurs. Pfeffer (Phys. of Plts. trans. by Ewart, **2**: 167. 1903) states that "only those cases ought to be designated as regeneration in higher plants in which the new parts formed after injury or loss exactly resemble in number and position the organs that have been removed." McCallum (Bot. Gaz. **40**: 98. 1905) recognizes three forms of regeneration as follows: "(1) The part removed is entirely restored by the growth of cells immediately below the cut surface; (2) there is no growth of embryonic tissue at the wounded surface, but at a greater or less distance from it the organization of entirely new primordia which develop organs which replace those removed; (3) the organ removed is restored by the development of already existing dormant buds." Dr. Kupfer (Mem. Tor. Bot. Club **12**: 196. 1907) says "The word regeneration ought to be limited to those cases in which an organ is formed, *de novo*, at a place or under conditions in which it would not normally be formed."

In the broadest sense of the term this form of reproduction in *Drosera* may be termed regeneration, but since it may occur on portions of the plant which are still attached to the main axis, without the apparent stimulus of injury, it seems better to place it in the category of plants that reproduce by budding than as an example of regeneration. However it is an illustration of a principle which much of the work on regeneration teaches, that the different forms of reproduction in plants may be arranged in a scale of slight gradations.

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JUGLANDACEAE FROM THE PLEISTOCENE OF MARYLAND *

By Edward W. Berry

Some years ago a very complete account of the Pleistocene flora of Maryland was given by Dr. Hollick † who enumerated

* Illustrated with the aid of the Catherine McManes fund.

† Hollick, Maryland Geol. Surv., Pliocene and Pleistocene, 217–237, pl. 67–75. 1906.